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[B.Sc (Prog.) Physical Science (Sec-A)-IV Semester]—Physical Chemistry

Order of Reactions

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The Order of reaction refers to the relationship between the rate of a chemical reaction and the concentration of the species taking part in it. In order to obtain the reaction order, the rate expression (or the rate equation) of the reaction in question must be obtained.

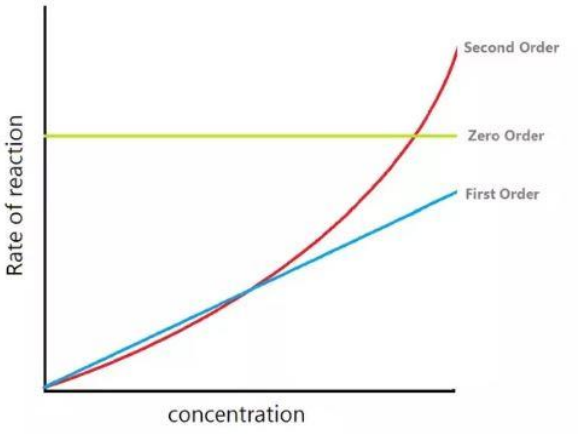
The order of reaction can be defined as the power dependence of rate on the concentration of all reactants.

Some characteristics of the reaction order for a chemical reaction are listed below--

- Reaction order represents the number of species whose concentration directly affects the rate of reaction.
- It can be obtained by adding all the exponents of the concentration terms in the rate expression.
- The order of reaction does not depend on the stoichiometric coefficients corresponding to each species in the balanced reaction.
- The reaction order of a chemical reaction is always defined with the help of reactant concentrations and not with product concentrations.
- The value of the order of reaction can be in the form of an integer or a fraction. It can even have a value of zero.

Different Values of Reaction Order

As discussed earlier, the value of the order of reaction may be in the form of an integer, zero, or a fraction. A graph detailing the reaction rates for different reaction orders can be found below.



Zero Order Reactions

- The rate of reaction is independent of the concentration of the reactants in these reactions.
- A change in the concentration of the reactants has no effect on the speed of the reaction
- Examples of these types of reactions include the enzyme-catalyzed oxidation of CH_3CH_2OH (ethanol) to CH_3CHO (acetaldehyde).

First-Order Reactions

- The rates of these reactions depend on the concentration of only one reactant, i.e. the order of reaction is 1.
- In these reactions, there may be multiple reactants present, but only one reactant will be of first-order concentration while the rest of the reactants would be of zero-order concentration.
- Example of a first-order reaction:

  $\mathbf{2H_2O_2 \rightarrow 2H_2O + O_2}$

Pseudo-First Order Reactions

- In a pseudo-first order reaction, the concentration of one reactant remains constant and is therefore included in the rate constant in the rate expression.
- The concentration of the reactant may be constant because it is present in excess when compared to the concentration of other reactants, or because it is a catalyst.
- Example of a pseudo-first order reaction:

  $\mathbf{CH_3COOCH_3 + H_2O \rightarrow CH_3COOH + CH_3OH}$

  (this reaction follows pseudo-first order kinetics because water is present in excess).

Second-Order Reaction

- When the order of a reaction is 2, the reaction is said to be a second-order reaction.
- The rate of these reactions can be obtained either from the concentration of one reactant squared or from the concentration of two separate reactants.
- The rate equation can correspond to $\mathbf{r = k[A]^2}$ or $\mathbf{r = k[A][B]}$
- Example of a second-order reaction:

  $\mathbf{NO_2 + CO \rightarrow NO + CO_2}$

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